

## Physicians' New Colleague Joins Search for Human Ills

It was one of those everyday medical mysteries.

A woman entered Massachusetts General Hospital in Boston burning with fever. She was 74, born in Sicily, and had become ill five weeks before — with shaking chills, vomiting and spasms of pain in the upper abdomen and back.

### ELECTRONIC DOCTORS:

Computers in Medicine

By Cristine Russell

First of Two Parts

Doctors went about diagnosing the ailment in the traditional way. Later an experimental computer program named INTERNIST, in effect a mechanical doctor, was given a chance.

After a battery of tests and X-rays, the human doctors located a mass in the right lobe of the woman's liver. They diagnosed it as an abscess. Only after an operation did

the doctors discover that it was an infected cyst in the liver, resulting from a rare parasitic worm apparently contracted during her childhood in Sicily.

INTERNIST, which later was fed the patient's symptoms, test findings and personal history, sorted through its vast memory. The computer's first conclusion was the same as that of the physicians: an infected liver abscess. Then, after it asked a series of follow-up questions, the computer diagnosed the cause: "Echinococcal" (a type of parasite) cyst of the liver.

INTERNIST "did better than the original doctors," Dr. Jack Myers of the University of Pittsburgh said proudly of his computer brainchild. "They diagnosed the abscess but couldn't figure out why she had it until the operation was performed."

There are about 50,000 specialists in internal medicine around the country, but there is only one INTERNIST.

Assisted by an enormous bank of knowledge of internal medicine,

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this computer program can diagnose a tremendous range of diseases, from a heart attack to Waldenstrom's macroglobulinemia, the uncommon condition that recently killed director-choreographer Gower Champion.

After the symptoms, lab tests and patient history are supplied, the computer searches through its unparalleled memory of more than 500 ailments, narrowing down the possibilities and coming to a conclusion in five to 20 minutes, depending on the difficulty of the case.

After nearly a decade of development, this brainchild of Myers and computer expert Harry E. Pople is about to make its "real world" debut in what is considered the first broadly based, controlled clinical testing of artificial-intelligence in medicine.

INTERNIST, Myers said, has already been pitted against textbook medical cases for years and generally runs "neck and neck" with the human experts in diagnosing diseases.

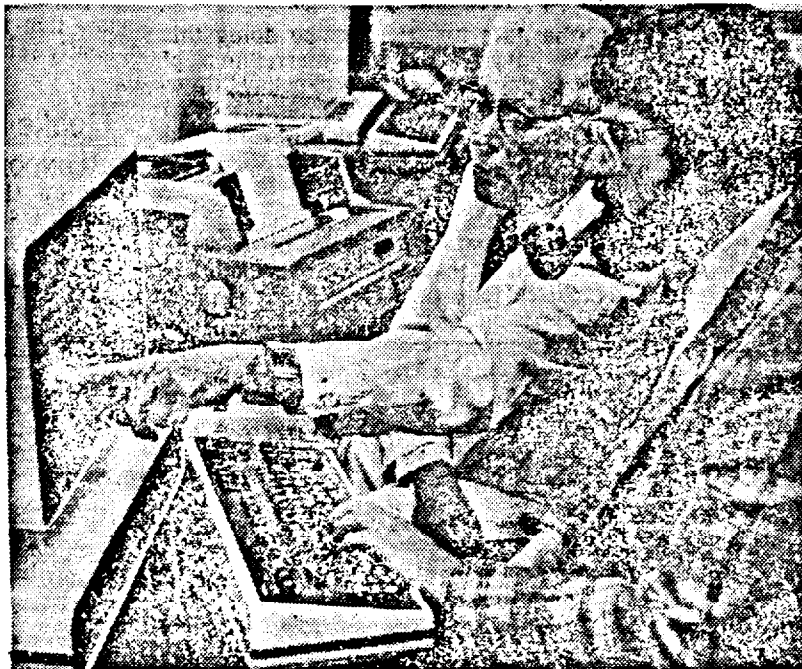
Given the favorable record in checking INTERNIST on this after-the-fact, theoretical basis, its creators are now ready to test the program on an experimental group of patients in Pittsburgh and elsewhere around the country.

With federal funding from the National Institutes of Health, field tests are set to begin within months, as soon as new computer hardware is installed to carry the load.

The emergence of INTERNIST in the rapidly growing field of artificial intelligence — computer programs modeled on human reasoning — is a milestone that could make it possible for computers to change the way medicine is practiced.

"Until now the artificial-intelligence community has been reluctant to make any promises. But we are now at a transition point. We can see the promises being realized," said Dr. William Baker Jr., an official at NIH's Biotechnology Resources Program who has helped shepherd the entry of computers into medicine.

"The field holds a lot of potential to reduce inequities that exist in the health enterprise," Baker said. "I see opportunities to move into underserved areas like Appalachia or the central cities, as well as remote areas served by the military. All a physician assistant or nurse practitioner would need would be a computer terminal and a telephone."



Dr. Jack Myers (white smock) of the University of Pittsburgh and computer expert Harry Pople are the developers of INTERNIST, the mechanical doctor.

- PUFF/VM. Researchers at San Francisco's Pacific Medical Center, in collaboration with Stanford, have developed two systems, one for diagnosing and treating pulmonary function, the other for monitoring the condition and progress of patients in intensive care whose breathing is assisted by ventilators.
- RX, a Stanford system for extracting data about the progress and treatment of chronic diseases from existing computer data banks at several centers in the United States. Initial work is beginning with arthritis.

"The whole field is exploding," said Dr. Joshua Lederberg, Rockefeller University president and former Stanford University genetics professor, who helped in the development of SUMEX in the mid-1960s.

Still, the movement of medical programs into practical use has been slow, largely because of the difficulties of translating the loosely organized branches of medicine into artificial-intelligence programs.

Physicians are fond of saying that medicine is as much an art as a science, but computer wizards contend that it is possible to capture and organize the knowledge of medical specialists.

Rather than using the numerical calculations that have characterized traditional computer programming, artificial-intelligence researchers have taken a different approach, called "symbolic computation." This allows them to organize the abstract and largely informal (or "heuristic") decision-making rules used in the real world of medicine into workable computer programs.

The head of Stanford's SUMEX program, Dr. Edward Feigenbaum, called this "knowledge engineering" instead of the "more inflammatory" term artificial intelligence. In addition to practical uses, Feigenbaum said that thinking computers in medicine will serve a broader purpose: demystifying medicine and forcing experts to come to grips with its unwritten methods.

"SUMEX-AIM is eliciting, organizing and polishing a body of knowledge that rarely sees the light of day," the Stanford scientist said. "It is the knowledge that underlies the expertise of practice, the knowledge that is normally transmitted by a kind of osmosis process from master to apprentice. That knowledge will now be codified, taught, used and critiqued."

For this ideal to work requires a unique marriage of computer and medical experts. In the case of INTERNIST, observers agree that the success of the program thus far is a result of the involvement of Myers, an internist whose own broad experience of over 40 years has brought a practical working knowledge to the program.

Although Myers' INTERNIST program is one of the broadest of the new intelligent computers in science and medicine, it is not alone. It is part of a network under the so-called SUMEX-AIM (short for Stanford University Medical Experimental Computer for Artificial Intelligence in Medicine) program.

SUMEX-AIM is a shared computer resource, funded by NIH, that is devoted to applying new artificial intelligence techniques to biomedical science, from biochemistry to psychology. Under the stewardship of Stanford University, known as the "nursery of applied artificial intelligence," SUMEX's alphabet-soup offspring include:

- DENDRAL, a pioneering program, begun about 15 years ago, that demonstrated that abstract theories of artificial intelligence could be applied successfully to practical problems — in this case, molecular structure problems in chemistry. A related program to aid chemists, called CONGEN, has been used for five years by both university and industrial scientists and exported to the United Kingdom.

- MOLGEN, a computer aid developed by Stanford and University of New Mexico scientists to help geneticists design DNA experiments.

- MYCIN, a Stanford program that specializes in the diagnosis and treatment of patients with specific infectious diseases, such as meningitis. The basic MYCIN model has been extended to other projects, including a new management program to help determine the proper treatment program for patients at the Stanford cancer clinic, expected to be tested within a year.

MYCIN researchers have also been able to branch out of medicine to solve problems in engineering. And another spinoff, GUIDON, offers a computer tutor for medical students.

- HEADMED, a program under development at the University of Texas Medical Branch at Galveston to help address drug misuse in psychiatry. In the short term, the program seeks to recommend drug therapy for psychiatric problems. Eventually, its designers hope, HEADMED will be able to diagnose disorders as well.

- CASNET, a prototype Rutgers University artificial intelligence program for diagnosing and treating eye diseases — specifically glaucomas. Today, the same approach is being applied in an EXPERT program for diagnosis and treatment of rheumatic diseases, from arthritis to connective tissue disorders.

With his white crewcut and matter-of-fact manner, the 67-year-old Myers fits the stereotype of the old-fashioned family doctor many people wish they had. But his appearance belies a forward-looking approach uncommon among many of his colleagues.

Myers turned to computers after concluding that "no man alone, myself included, knows all the medical information in our knowledge base."

When he graduated from Stanford Medical School in 1937, he said, it was "no problem for the human brain to encompass the field of internal medicine. A smart professor could come on a ward of 20 patients and tell in two hours all he knew. But the knowledge explosion since then has been high."

Concluding that "it's going to get worse, not better," Myers reached for a computer — not only for storing and retrieving medical knowledge, but manipulating it as well. Myers and Pople, a young computer expert, set out to fashion a machine that could think and act like a doctor, taking in symptoms and coming up with the likely diagnoses.

Although they have already programmed knowledge of more than 3,400 "manifestations" (symptoms, lab tests, etc.) and 500 diseases into INTERNIST, the designers plan to complete its repertoire over the next few years. Most the testing of the computer's ability to diagnose cases has been based informally on comparisons with the recommendations of experts cited in case histories in the prestigious New England Journal of Medicine, such as that of the Sicilian woman.

"In hundreds of cases thus far, we do just as well as the experts. But we're still at the stage of research and development," Myers said. He and his federal sponsors believe, however, that the program has reached a "critical mass" sufficient to allow testing on patients.

They will begin on a ward at the University of Pittsburgh teaching hospital and attempt to analyze every case admitted, comparing the findings of the machine against those of the human doctor in charge. "Then we'll provide the analyses to the physicians and house staff and they can do what they want with it," Myers said.

Operating on the old rule that "two heads are better than one," he said he expects doctors will welcome assistance from their learned new colleague.

**Tomorrow: The Ethics of Change**